



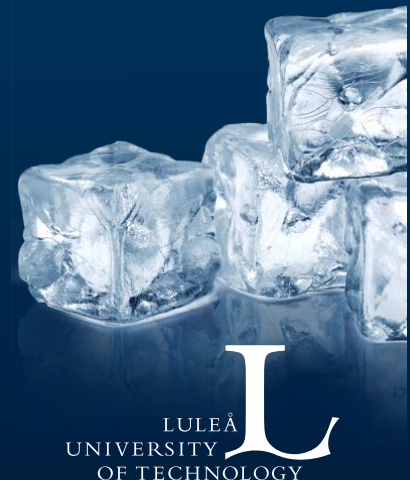
Photogrammetry for surface flow velocity measurements

October, 2020

Hang Trieu, Lulea University of Technology

**Supervisors: Gunnar Hellström, Mikael Sjö Dahl, Patrik Andreasson
and Per Bergström**

Lulea University of Technology





Contents

1 Introduction

2 Methodology

3 Results and discussion

4 Ongoing works

The background of the slide is a deep blue gradient. At the top, there is a horizontal band showing a close-up of icebergs floating in water, with their jagged edges and textures clearly visible. The water below the icebergs is dark and reflects the light. In the bottom right corner, there is a small, detailed image of several clear ice cubes stacked together on a reflective surface.

Introduction

Research background

Introduction / Methodology/ Results and Discussion/ Ongoing works

- Measuring flow velocity of rivers is major task in hydrometry because of its importance in many hydrological research questions, e.g. to determine the discharge of rivers, to explore eco-hydraulic issues.
- Outdoor, the **difficulties in flow measurement** by traditional methods (i.e time consuming, limited area, safety requirement) can be overcome by **utilizing image-based approaches**.



Flow measurement by traditional method (M.Hassan Nasermoaddeli , 2015)

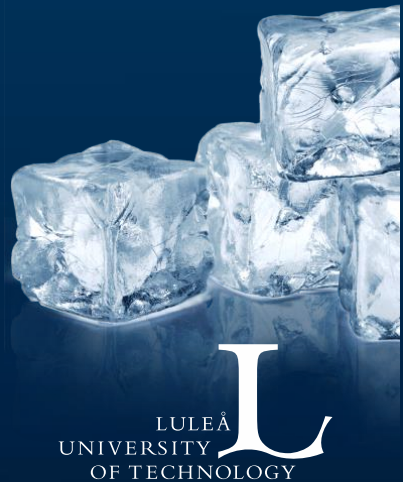


Image-based surface flow velocity

Research objectives

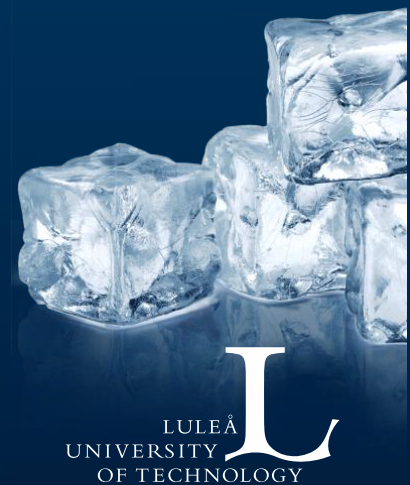
Introduction / Methodology/ Results and Discussion/ Ongoing works

- To develop further Image analysis technique to measure hydropower flows (with and without seeding).
- To focus on techniques that does not interfere with normal plant operation.



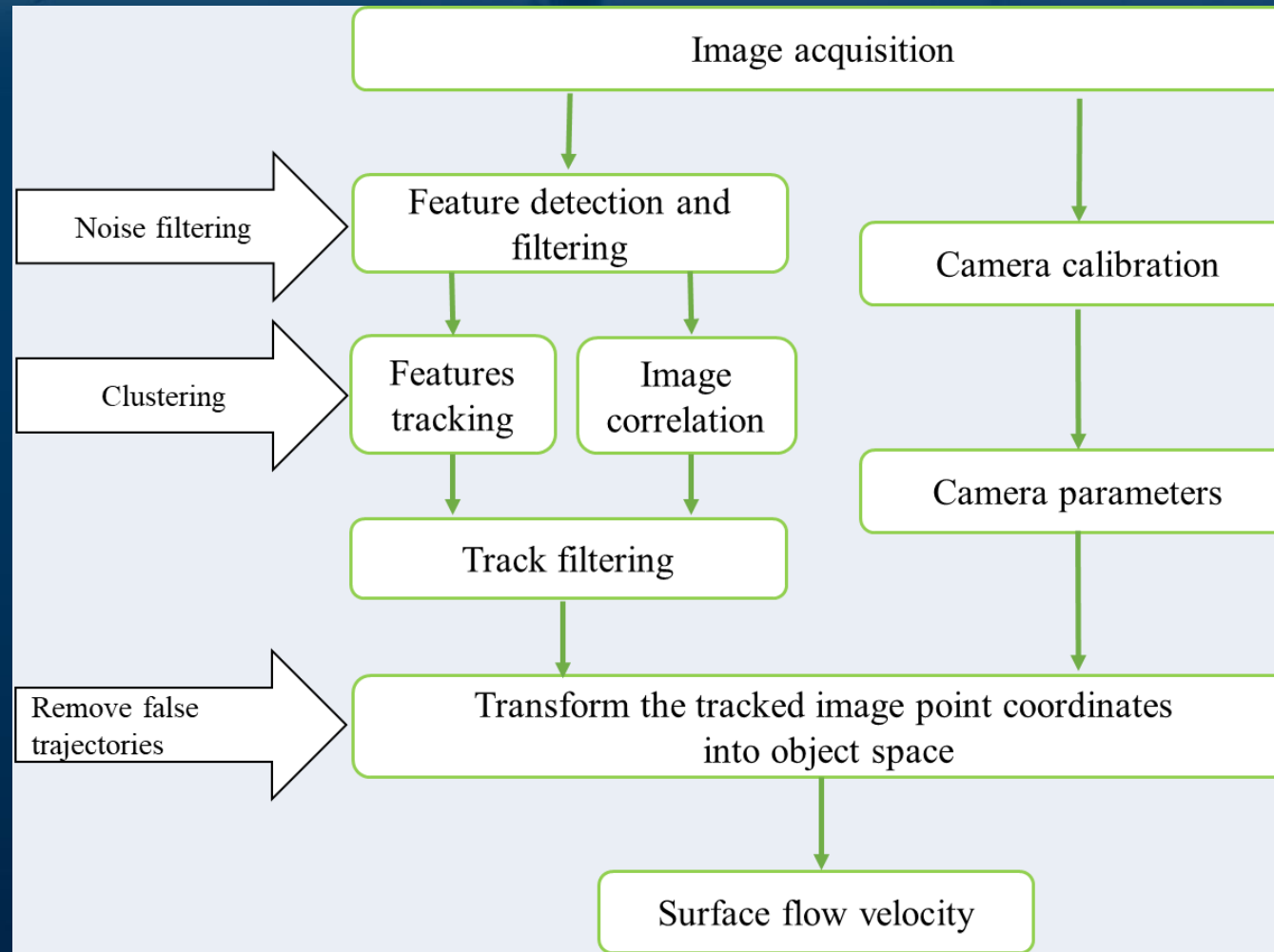


Methodology

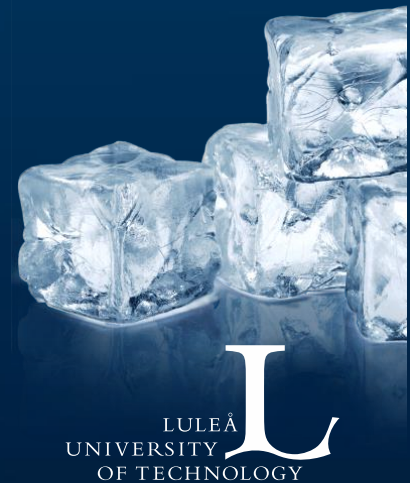


Workflow

Introduction / **Methodology** / Results and Discussion / Ongoing works

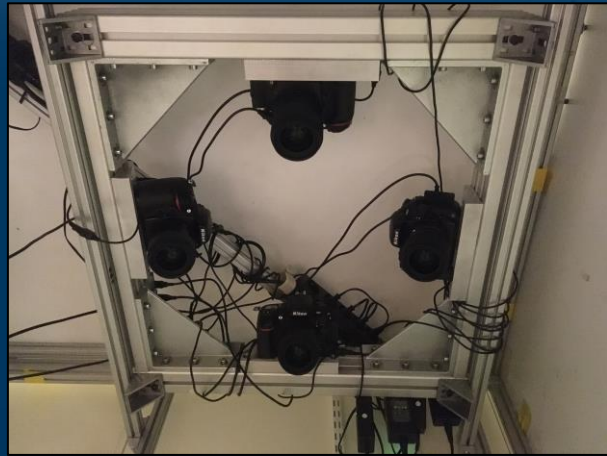


Workflow of image-based surface flow velocity measurement



Laboratory setup

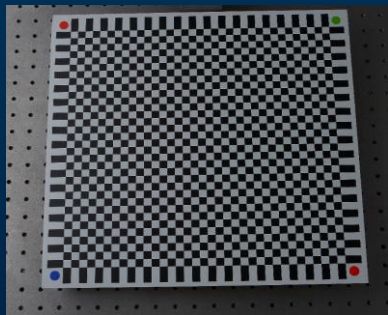
Introduction / **Methodology** / Results and Discussion / Ongoing works



Camera system



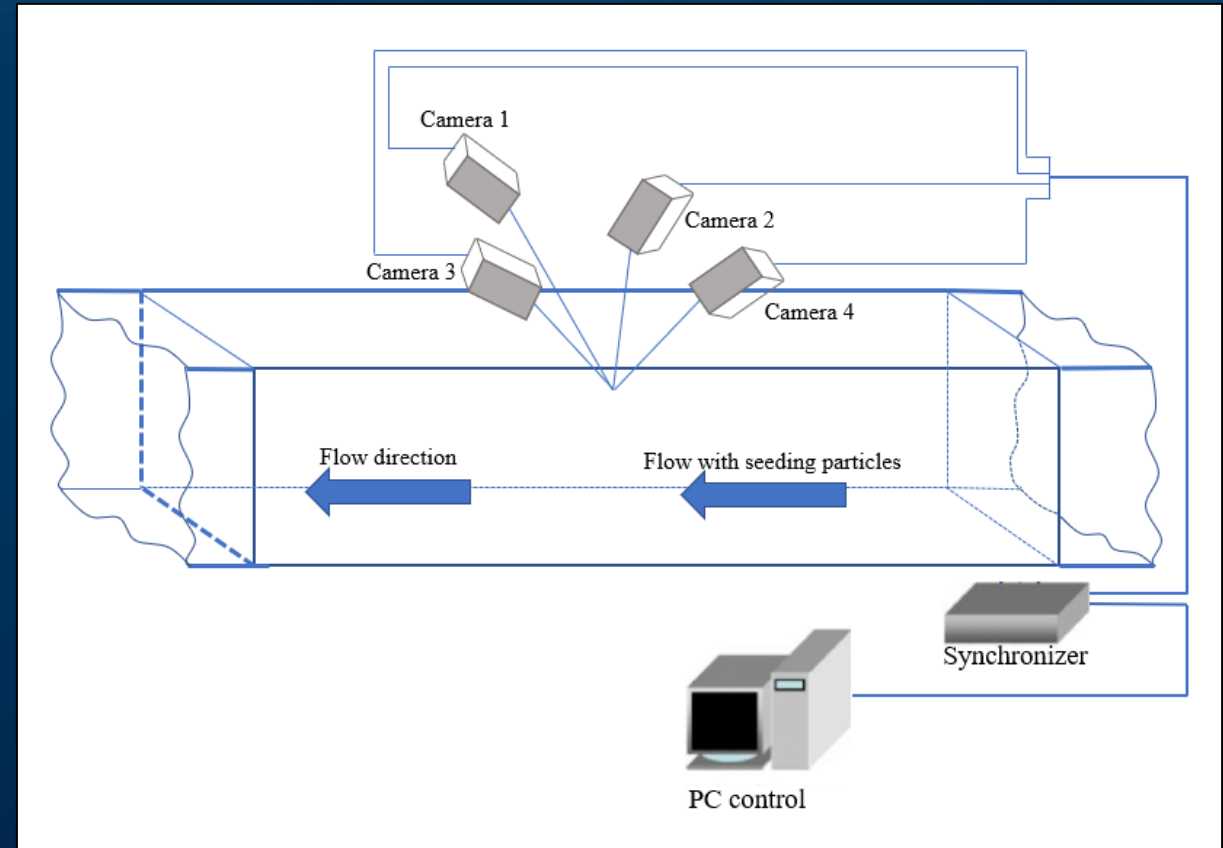
Photogrammetry box



Checkerboard Pattern –
Laboratory calibration



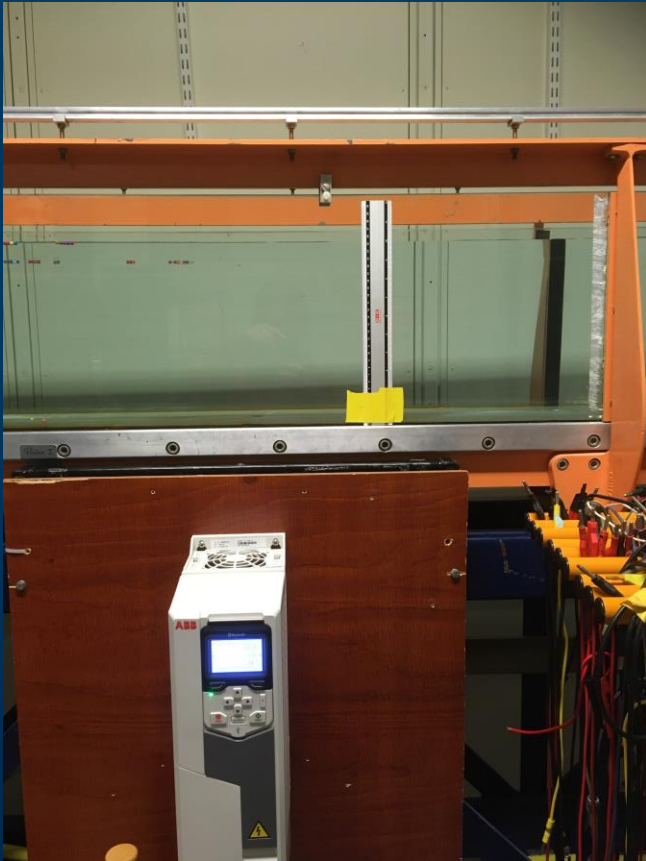
Seeding particles -
Wooden bead



Experimental setup of photogrammetry-based
flow measurement

Laboratory experimental setup

Introduction / **Methodology** / Results and Discussion / Ongoing works



Pump controller



Water depth



Flow surface seeding



Lab experimental setup

Introduction / **Methodology** / Results and Discussion / Ongoing works



Image of channel flow with seeding particles

Field measurement setup

Introduction / **Methodology** / Results and Discussion / Ongoing works

Surface velocity measurement at
Svedjebron (Boden, Norrbotten)



Field measurement setup

Introduction / **Methodology** / Results and Discussion / Ongoing works



Natural pattern on
water surface



Orange
(Particle tracking)

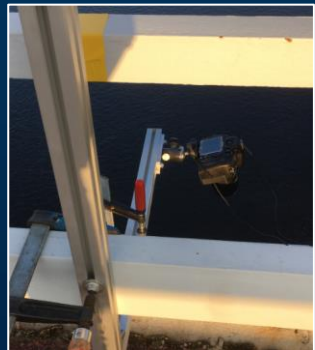


Puffed corn
(Image correlation)



Leaf
(Image correlation)

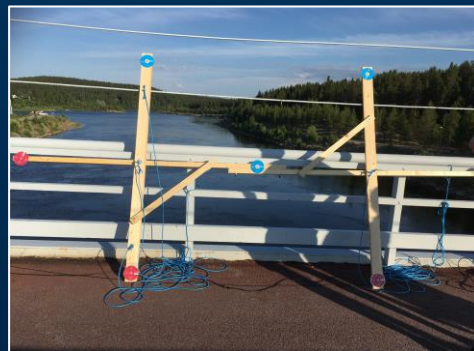
Adding traceable
particles



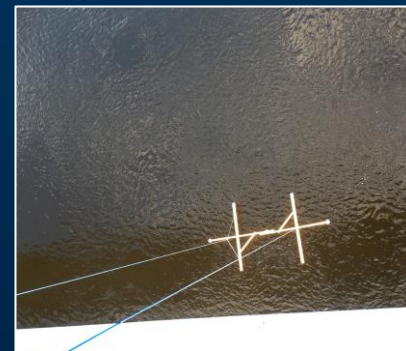
2 Cameras Nikon
D800



Natural pattern for
interior camera
calibration (Agisoft)



Reference wooden frame for
exterior camera calibration



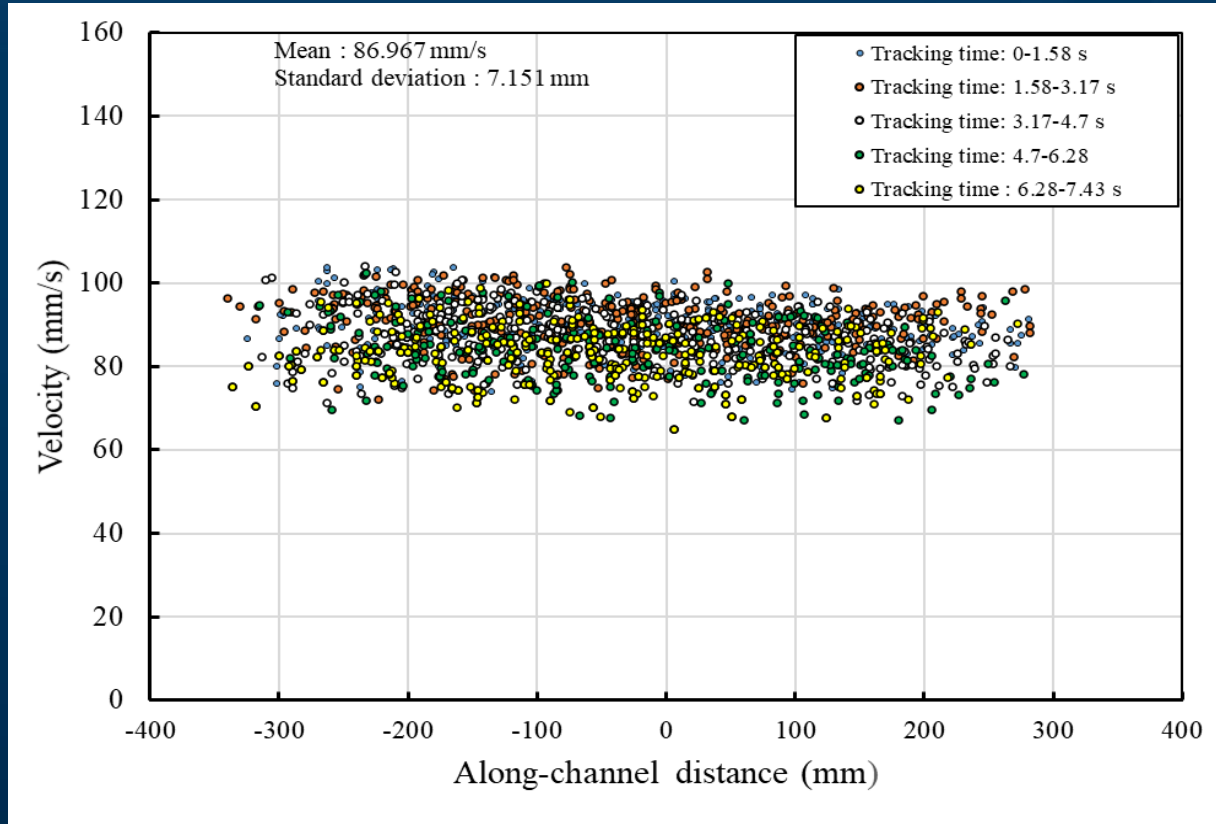


Results and Discussion

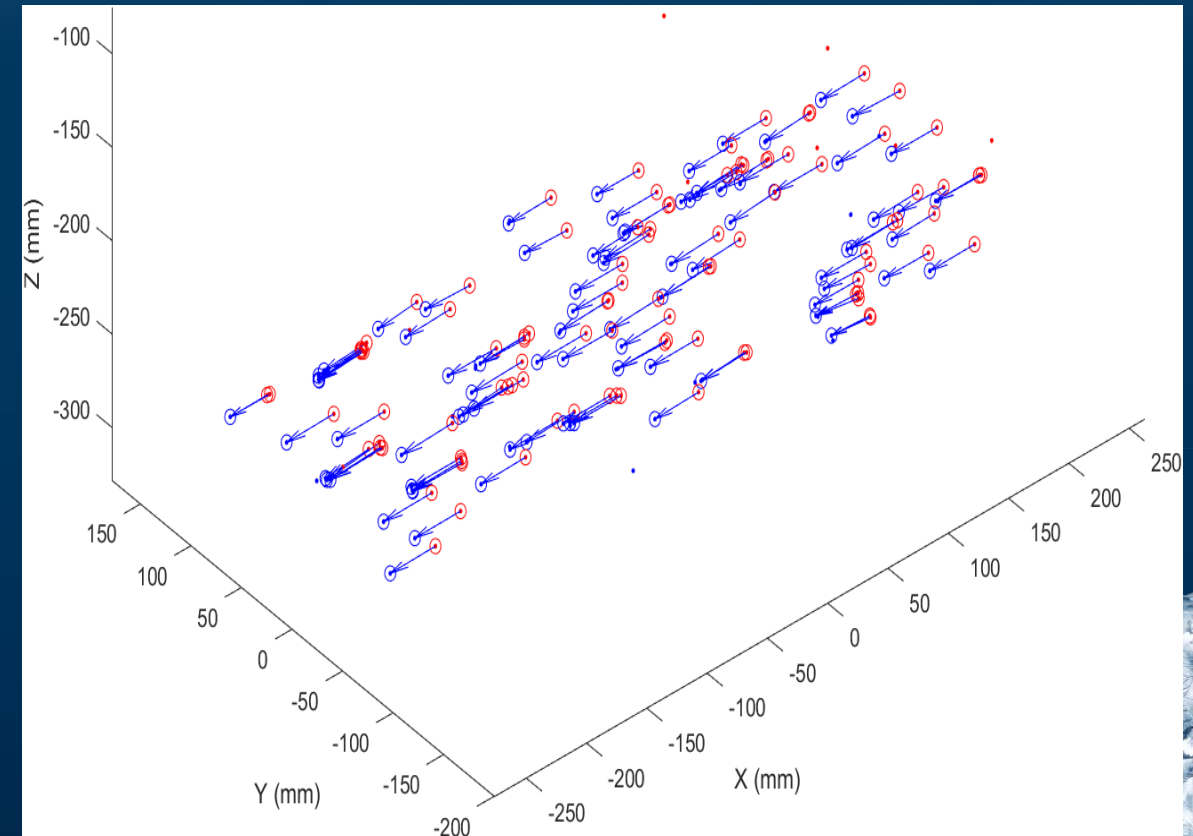


Channel flow velocity (Laboratory)

Introduction / Methodology/ **Results and Discussion**/ Ongoing works



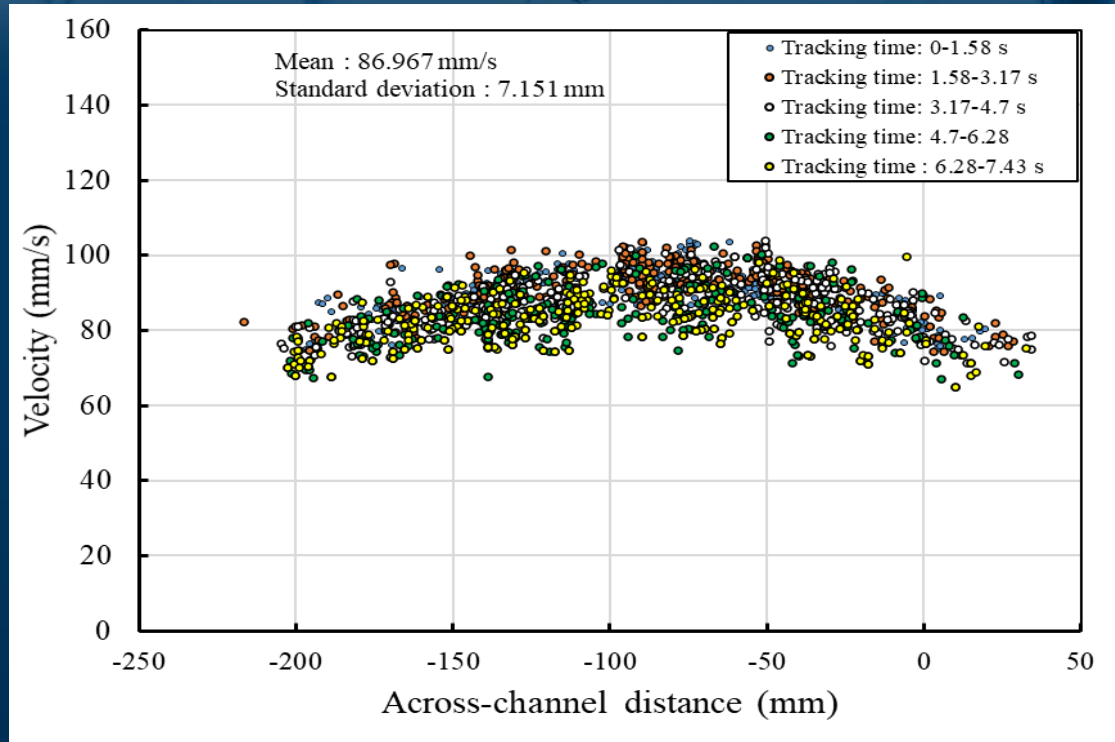
Surface velocity distribution along-channel from 5 groups of particles



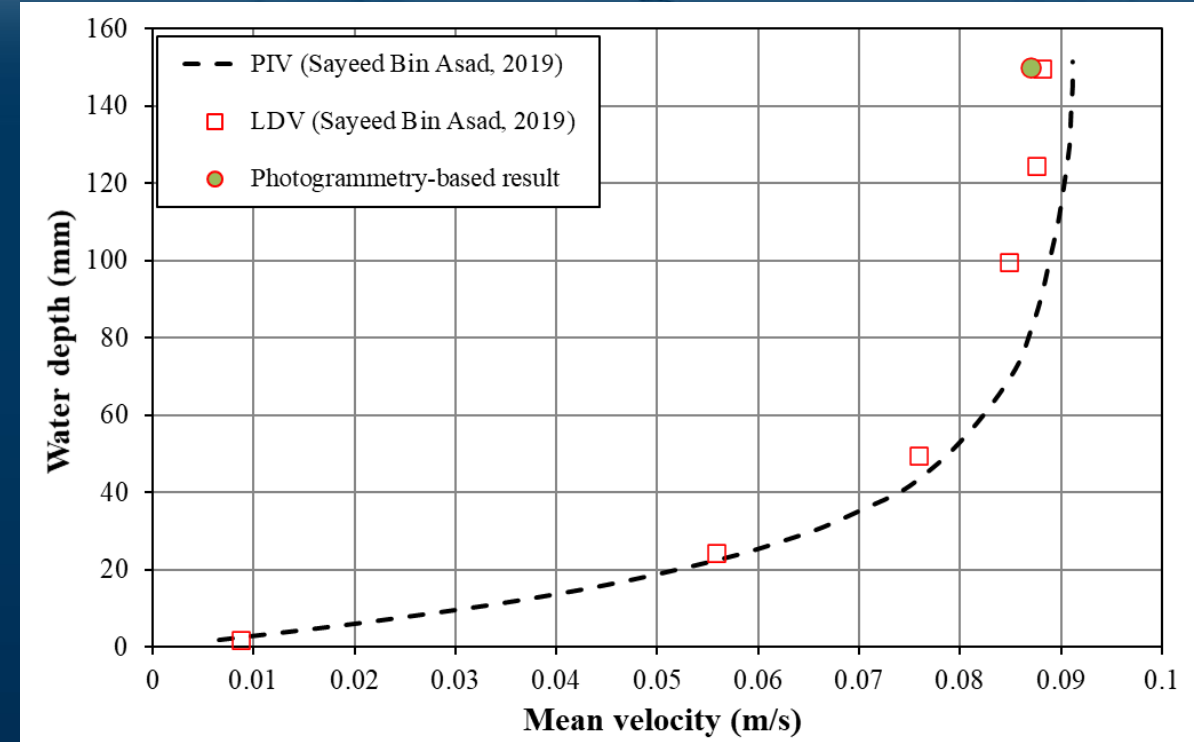
Movement of detected particles in 3D by two consecutive frames

Channel flow velocity (Laboratory)

Introduction / Methodology/ **Results and Discussion**/ Ongoing works



Surface velocity distribution across-channel from 5 groups of particles



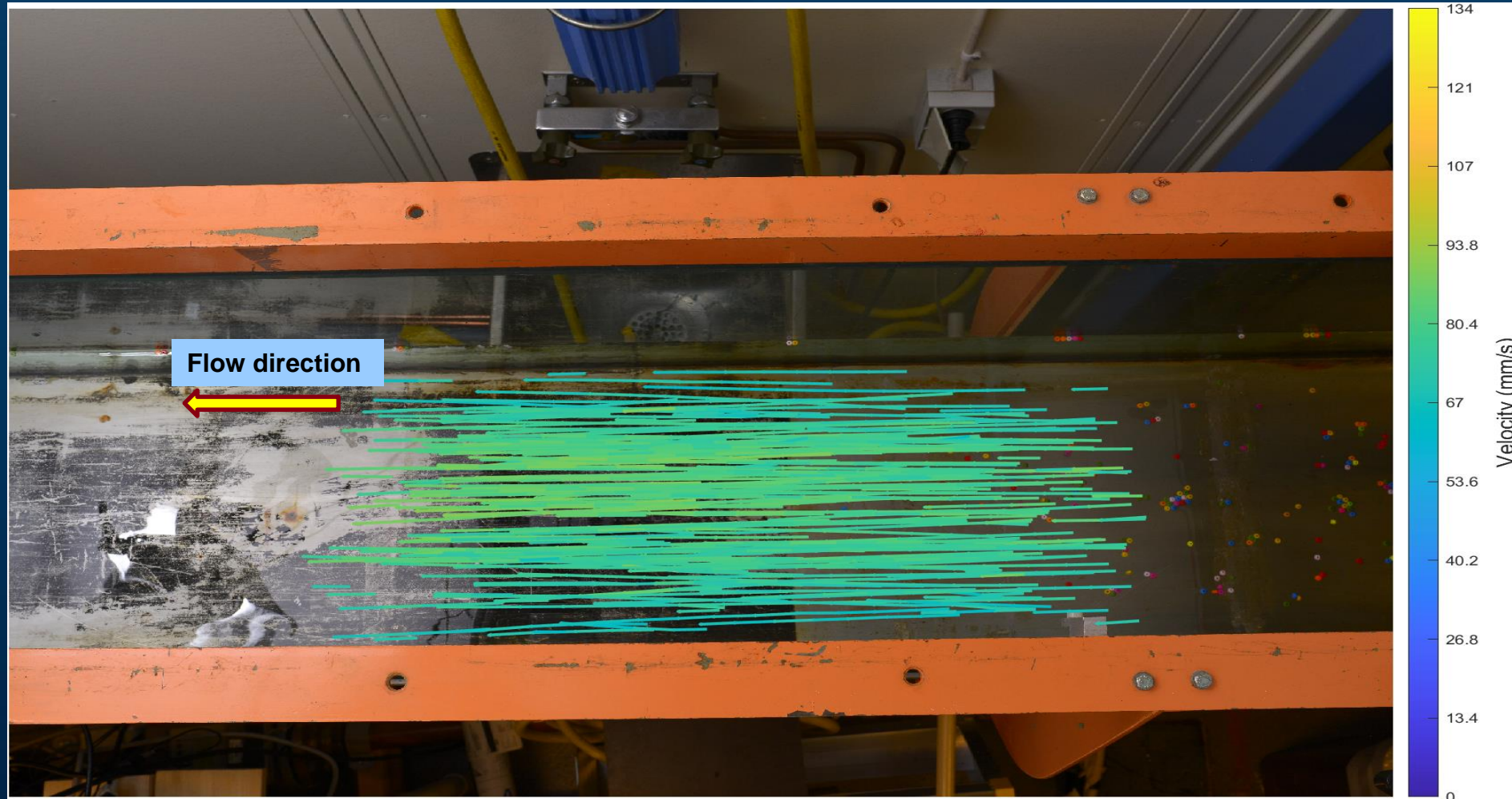
Velocity profile in open channel

- A good agreement between surface velocity from velocity profile and photogrammetry-based result.

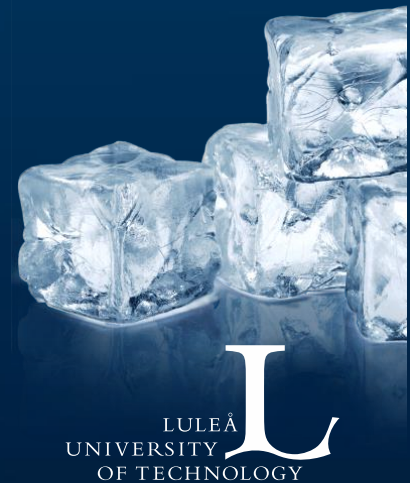


Channel flow velocity (Laboratory)

Introduction / Methodology/ **Results and Discussion**/ Ongoing works

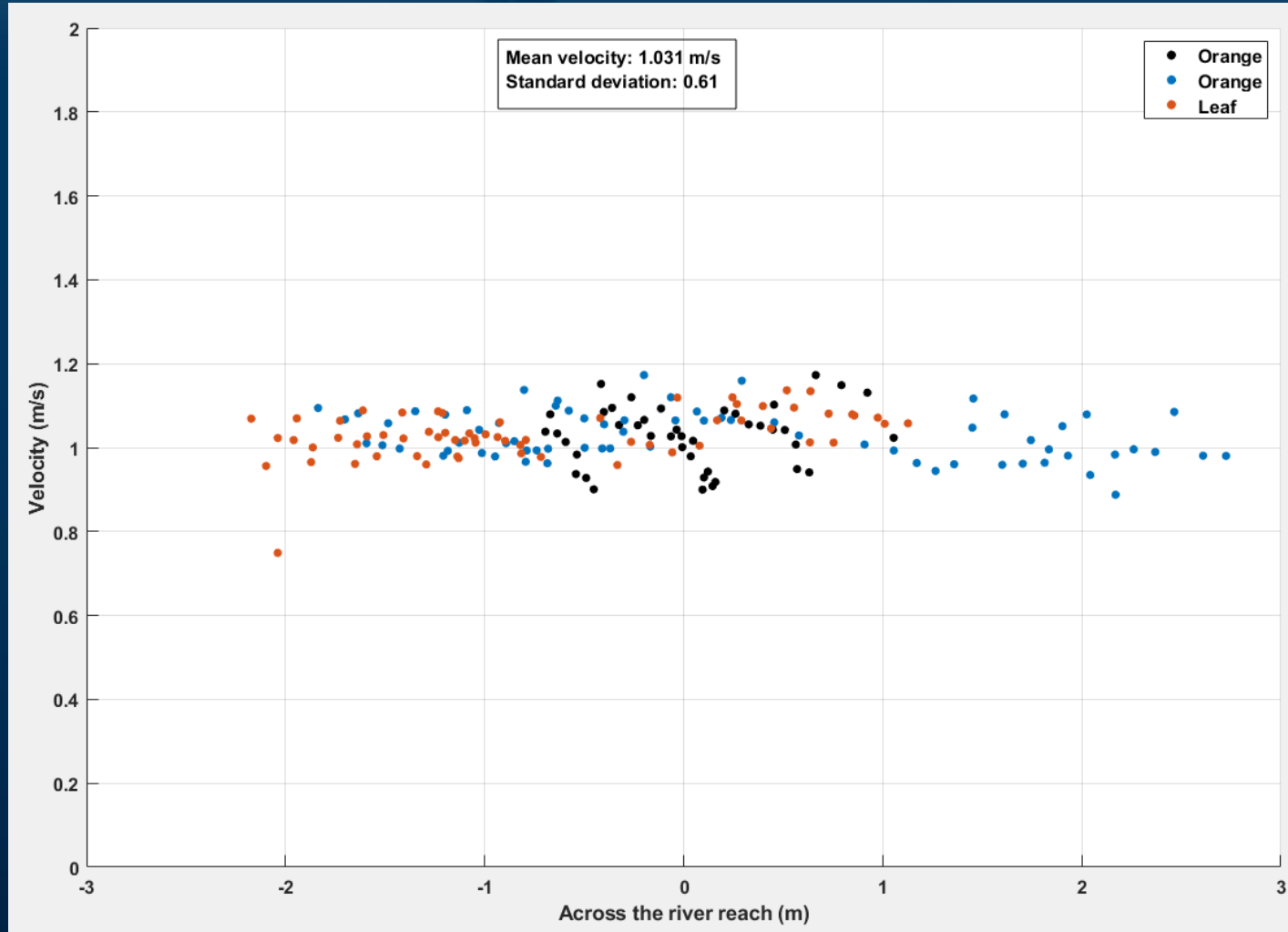


Surface flow velocity

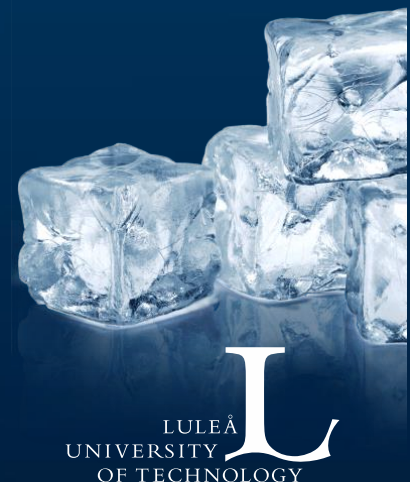


River flow velocity- Field measurement day 1

Introduction / Methodology/ **Results and Discussion**/ Ongoing works

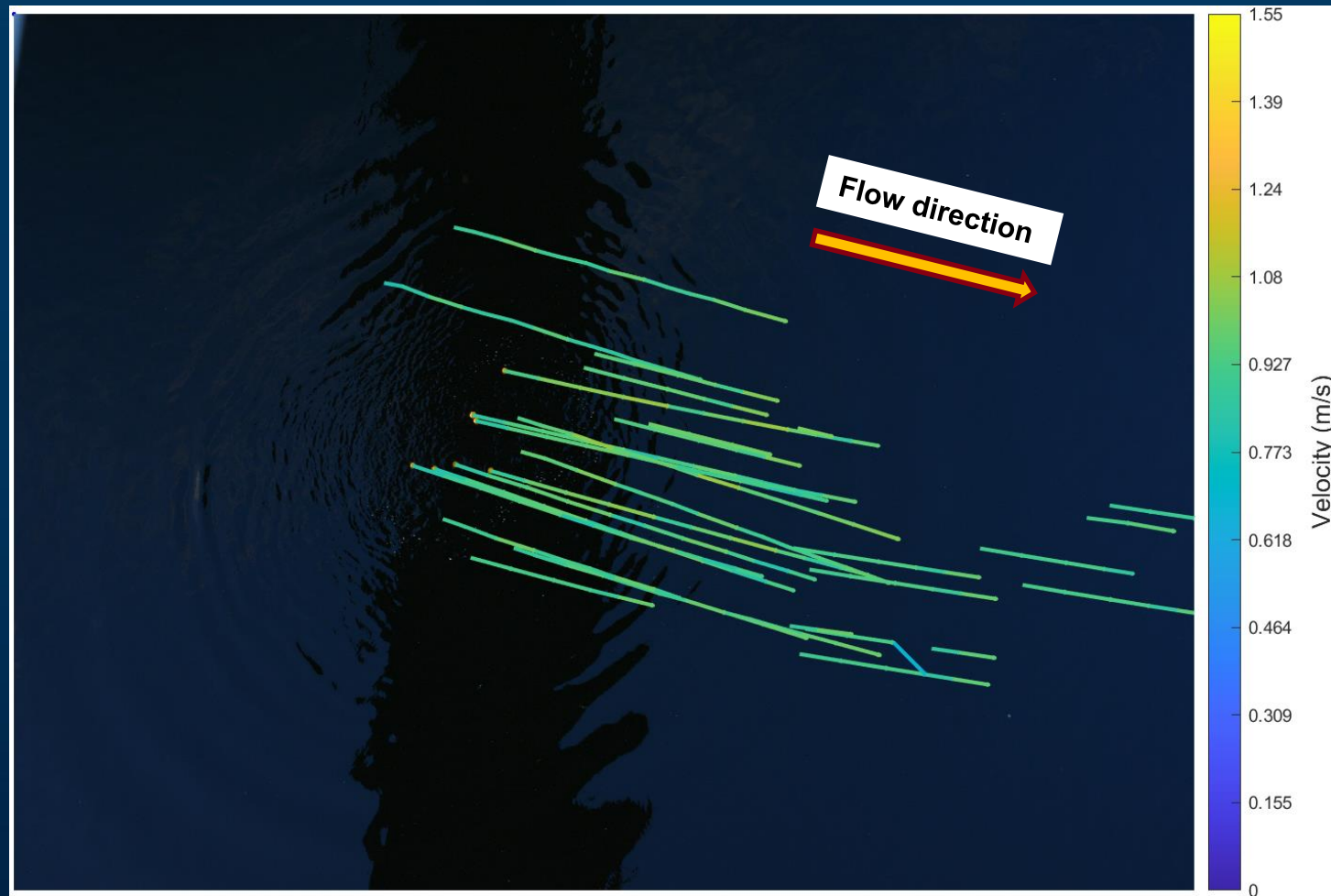


Surface flow velocity distribution across the river reach

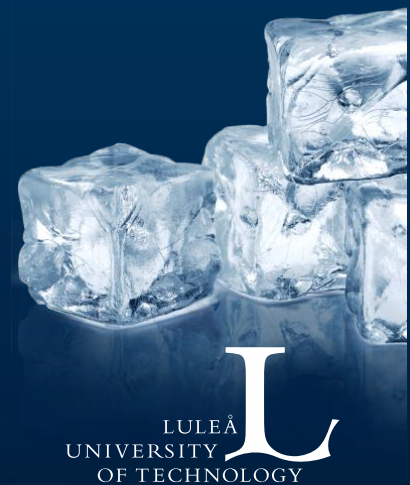


River flow velocity- Field measurement day 1

Introduction / Methodology/ **Results and Discussion**/ Ongoing works

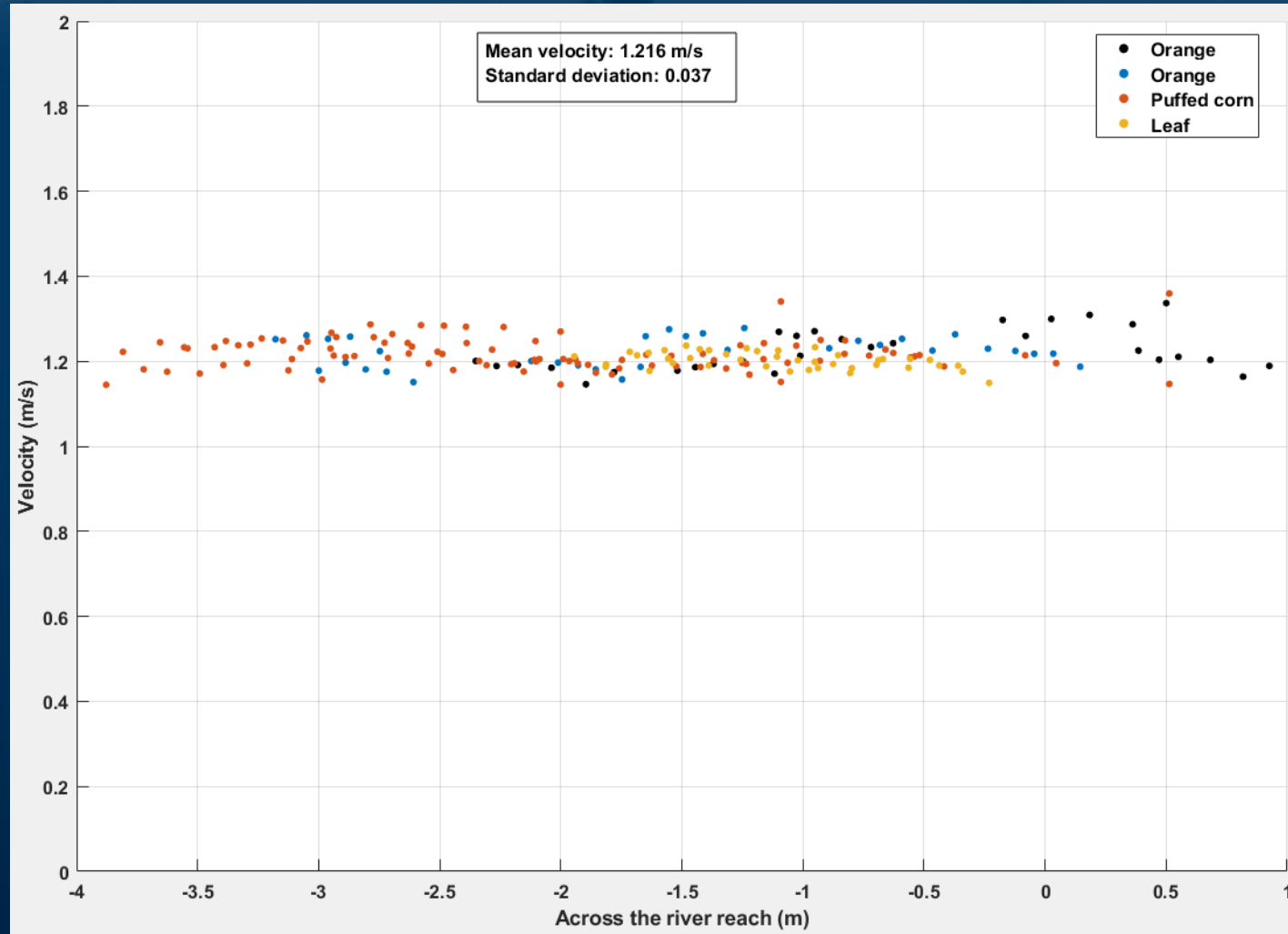


Surface flow velocity

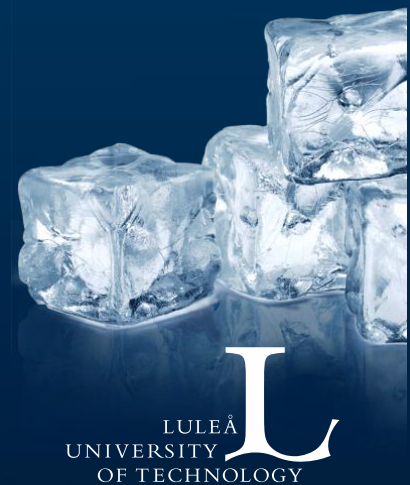


River flow velocity- Field measurement day 2

Introduction / Methodology/ **Results and Discussion**/ Ongoing works

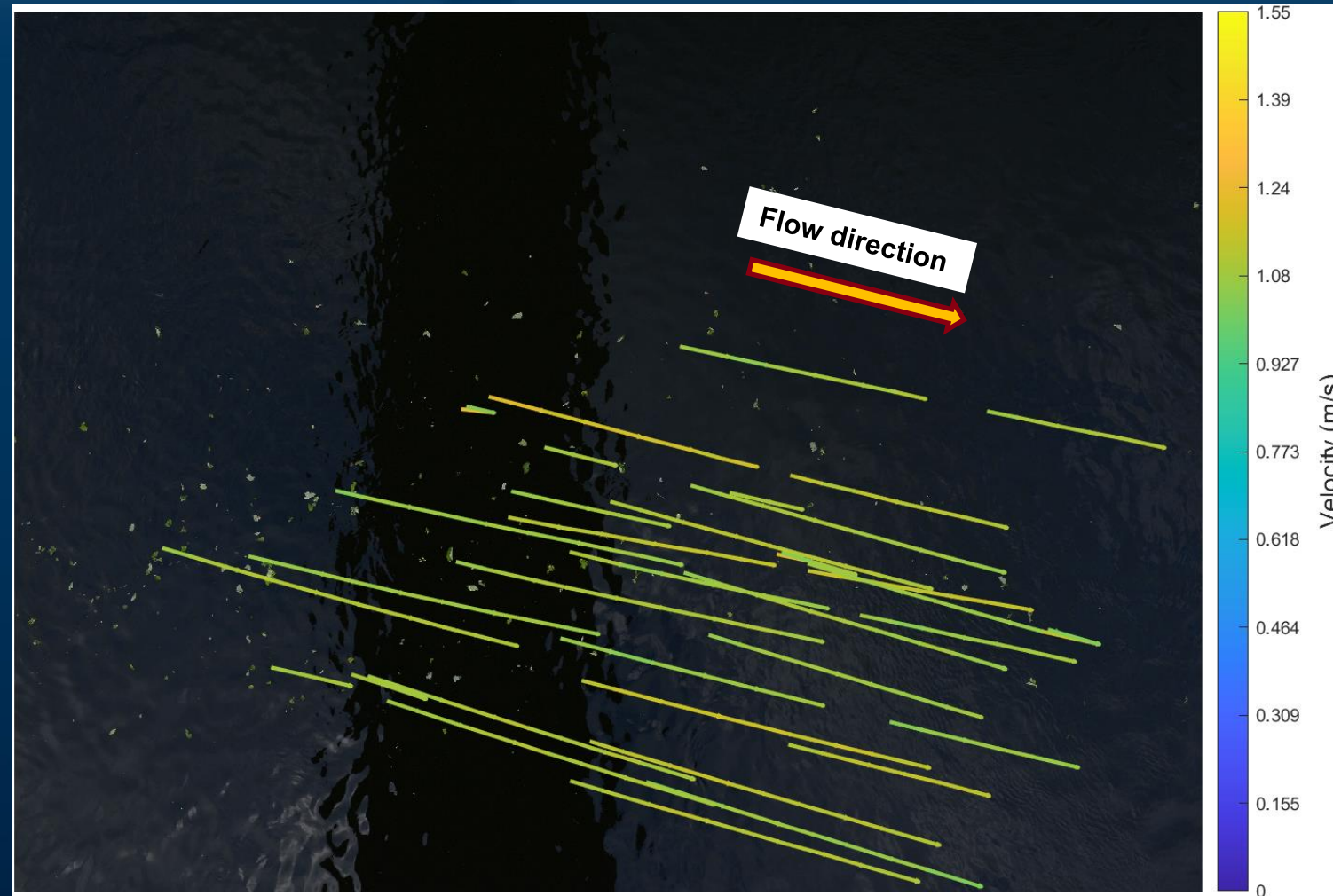


Surface flow velocity distribution across the river reach



River flow velocity- Field measurement day 2

Introduction / Methodology/ **Results and Discussion**/ Ongoing works



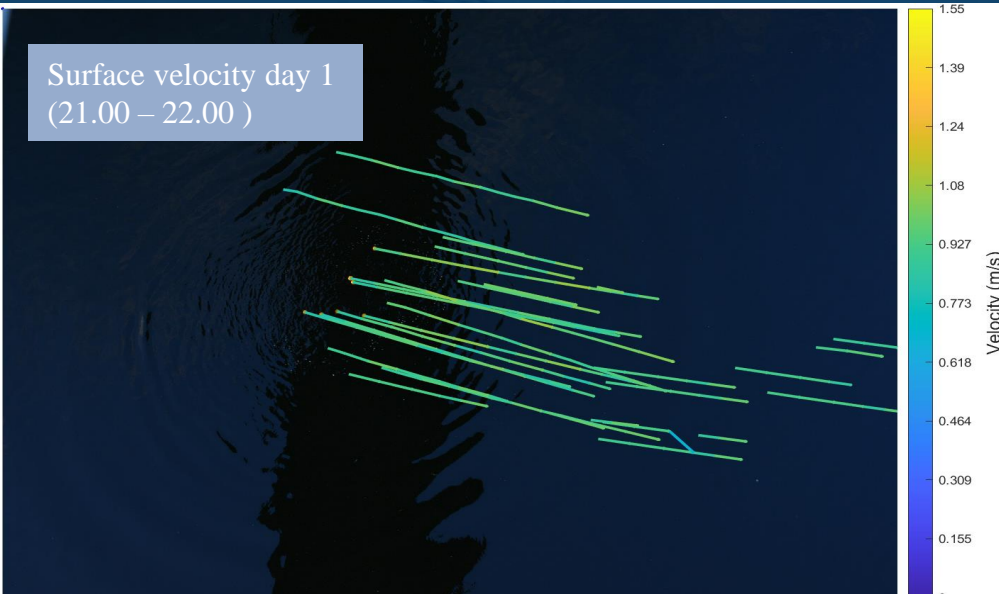
Surface flow velocity



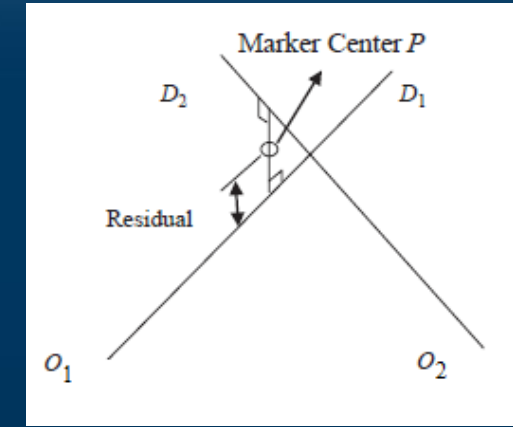
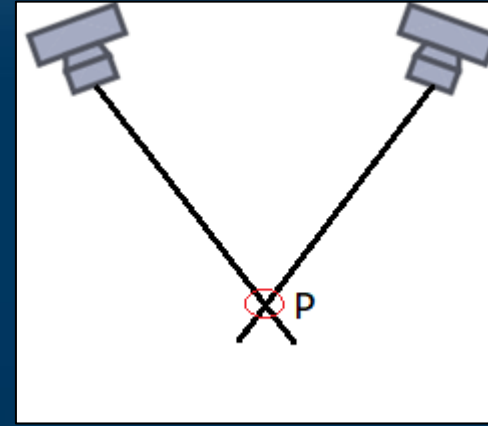
River flow velocity- Field measurement day 1 and 2

Introduction / Methodology/ **Results and Discussion**/ Ongoing works

Surface velocity day 1
(21.00 – 22.00)



Surface velocity day 2
(19.00 – 20.00)



Intersection of Rays defines object point

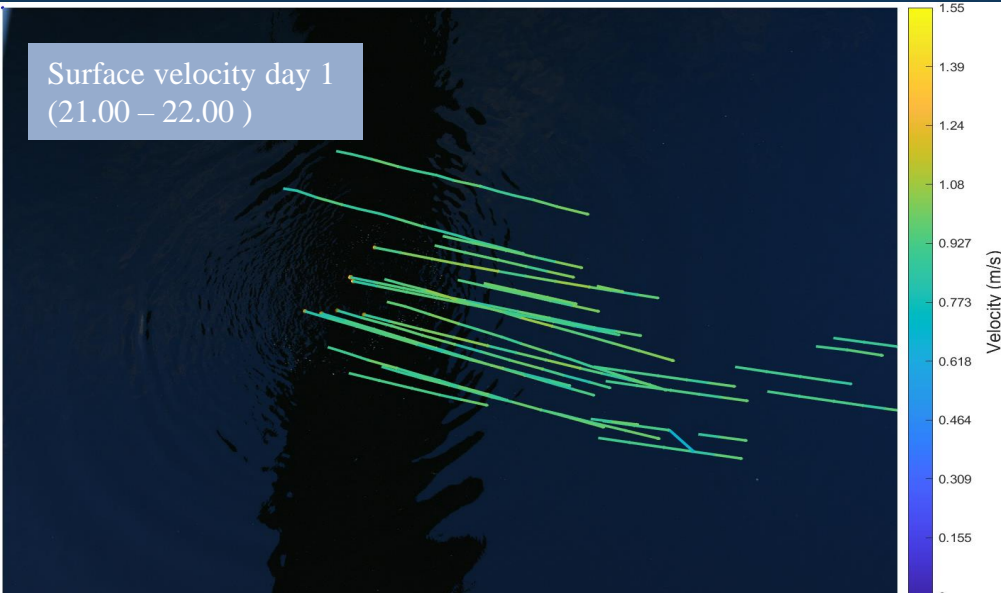
Parameter	Measurement day 1	Measurement day 2
Extrinsic reprojection error (Total RMS error in pixel)	Camera 1: 8.09 Camera 2: 6.75	Camera 1: 6.413 Camera 2: 8.487
Convergence – Intersection of Rays (Total mean residual in mm)	5.715	6.976

Photogrammetric accuracy

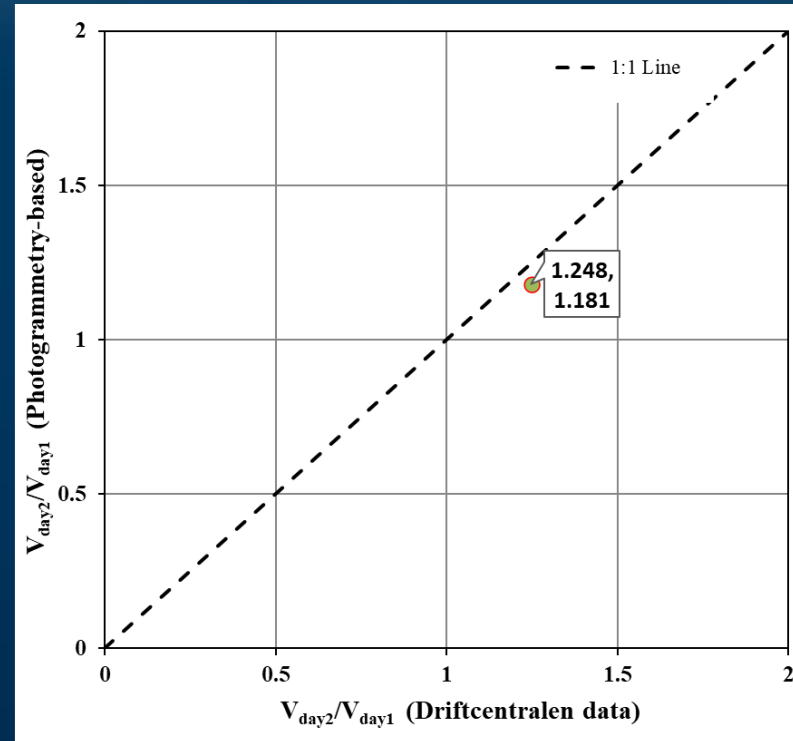
River flow velocity- Field measurement day 1 and 2

Introduction / Methodology/ **Results and Discussion**/ Ongoing works

Surface velocity day 1
(21.00 – 22.00)



Surface velocity day 2
(19.00 – 20.00)



Comparison between photogrammetry-based
and Driftcentralen data

- The changes in flow velocity by photogrammetry correlates with the changes of flow-rates.
- The measurement of surface flow velocities can be enabled independently.
- With the non-contact measurement, simple setup, spatially distributed surface velocity fields can be obtained.

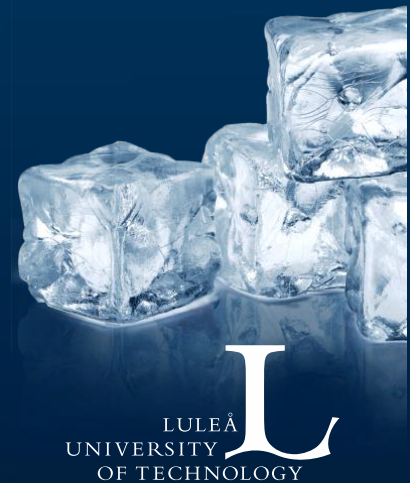
The background of the slide features a deep blue gradient. At the top, there is a horizontal band showing a close-up of icebergs floating in water, with their complex, jagged structures and reflections visible. In the bottom right corner, there is a small, detailed image of several clear ice cubes stacked together, also reflecting light.

Ongoing works

Ongoing works

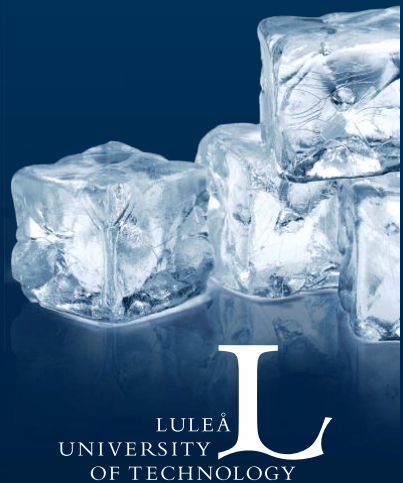
Introduction / Methodology/ Results and Discussion/ **Ongoing works**

- Measure rapid water flow using high speed cameras.
- Use only nature structure floating on rivers surface.



Acknowledgements

This research was supported by the Swedish Hydropower Centre.





Thank you very much!

